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DOCUMENT RESUME

ED 255 200 IR 011 572

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TITLE Some Uses of a Computer in Teaching, Training, and Testing: Student/Learner Self-Assessment Responding.
PUB DATE 10 Dec 84
NOTE 15p.
PUB TYPE Viewpoints (120) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Computer Assisted Testing; Computers; Models; *Multiple Choice Tests; Responses; Review (Reexamination); Schemata (Cognition); *Self Evaluation (Individuals); *Systems Approach
IDENTIFIERS Computer Uses in Education

ABSTRACT

The use of systems theory as a conceptual framework is proposed as useful when considering computers as a machine component in teaching. Skinner's proposal that the label "computer" is inaccurate and counterproductive when used to refer to a machine being used for teaching is discussed. It is suggested that the alternative label "teaching machine" has the disadvantage of being associated with the past failure of "teaching machines" to live up to their expectations. Three practical applications concerning the human "self-assessment" process are discussed: (1) self-assessment multiple choice test; (2) self-assessment computer aided testing; and (3) self-assessment computer aided instruction and review. It is concluded that the day-to-day behavior of people in home, work, and leisure situations depends on the ability of individuals to assess the correctness of their own responses, as well as on the knowledge and skills which they possess, and that learning might better be considered a change in a person from being unsure and wrong to being sure and correct. Ten references are listed. (Author/LMM)

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SOME USES OF A COMPUTER IN TEACHING, TRAINING, AND TESTING
Student/Learner Self-Assessment Responding

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Darwin P. Hunt
Experimental Training Center
Department of Psychology
New Mexico State University
10 December 1984

"The proud man...is an extreme in respect of the greatness of his claims, but a mean in respect of the rightness of them; for he claims what is in accordance with his merits, while others go to excess or fall short."

"...he who thinks himself worthy of great things, being unworthy of them is vain."

Aristotle, 4th century B.C.

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ABSTRACT

When considering computers as a machine component in teaching, training and testing it is useful to employ systems theory as a conceptual framework. Skinner's proposal that the label, 'computer,' is inaccurate and counterproductive when used to refer to a machine being used for teaching is discussed. An alternative label, 'teaching machine,' has the disadvantage of being associated with the past failure of "teaching machines" to live up to their expectations. Three practical applications based upon our own research concerning the human "self-assessment" process are discussed. They are (a) self-assessment multiple choice tests, (b) self-assessment computer aided testing and (c) self-assessment computer aided instruction and review. The underlying notion is that the day-to-day behavior of people in home, work and leisure situations importantly depends on the ability of a person to assess the correctness of their own responses as well as on the knowledge and skill which they possess. Thus, learning might better be considered a change in a person from being unsure-and-wrong to being sure-and-correct; it is insufficient to consider the learning objective simply to make correct responses.

INTRODUCTION

My explicit interest in trying to solve some problems of teaching was precipitated by my own experience when I first started teaching in 1962. For eleven years prior to that I had been employed as a Research Psychologist by the U.S. Air Force at their Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base in Ohio, where I conducted research and worked as a consultant to design engineers and manufacturers of aerospace systems in the area of, what may be called, Engineering Psychology and also in the multidisciplinary area of Human Factors or Ergonomics (I will use the latter two terms interchangeably).

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Ergonomists are essentially behavioral, social, physiological, medical and engineering scientists and professionals who develop knowledge in these areas of human science and apply it to the design, use and maintenance of technological systems and machines. The point of view assumed by most ergonomists and engineering psychologists is that machines may be considered to be extensions of a human's capacities; so that no machine, including a computer, has any reason for existence except for the use by humans (or, in some cases, by animals). Thus, computers are seen as machines which extend a person's abilities to process, manipulate, store and retrieve certain kinds of information.

During this presentation I want to

(a) provide a conceptual framework and a perspective for considering computers in teaching and testing, and

(b) describe three projects in which we have used computers to apply our basic research findings to instruction and testing.

It has been suggested by analyzers of the news that the emphasis during the television coverage of the recent national elections was on style (how the candidates looked, moved, etc.) and on the race-horse aspect (who is ahead, who is moving up, etc.) rather than on the substance and questions which would be more relevant and helpful to the voters' making good decisions. The implication is that the 'device' of television may have diverted people's interest and attention away from more important questions toward less important ones.

In a similar way, emphasizing the computer device, itself, rather than emphasizing the purposes and functions of teaching is likely to produce counterproductive attitudes in teachers, students, administrators, etc. and will direct our attention and energies to the wrong questions. Thus, I suggest that it is essential to construct first a conceptual framework for considering the numerous components which affect teaching effectiveness and costs. Without such a conceptual framework we will wander serendipitously from one component to another: From the teacher component ('The human teacher must be forced or enticed to teach better') to the student ('The student must spend more time on learning basic skills') to machines ('We must use more computers in teaching').

Not only is such component-thinking too simplistic to deal effectively with the complex teaching problems, but also such ineffective efforts are interpreted by many people as indicating that the problems are being solved when, in fact, they are not. Thus, these ineffective efforts are actually counter-productive because they divert money and resources away from more useful projects. The complexities of the problem are suggested by a recent article in the American Psychologist. Follman (1984), in a brief article entitled, "Pedagogue--Paragon and Pariah--20% of the time: Implications for Teacher Merit Pay," cites many studies from 1927 through 1977 conducted in different types of educational institutions which show "...that about 20% of teachers perceived as good, effective and best by some students are perceived as bad, ineffective, and worst by other students" (p. 1069).

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As behavioral and educational scientists, the task which is most challenging and demanding of our creative talents is that of formulating insightful questions which are both important and answerable. A conceptual framework is vital to serve as a guide for us to formulate good questions concerning the use of machines, including computers, in teaching. Systems theory (e.g., Miller, 1978), which will be discussed in more detail later, provides such a framework.

I will use as a point of departure a recent article by Skinner (1984) entitled, "The shame of American education." He argues that educators and teachers have not seized the chance to improve teaching because "...the solution conflicts with deeply entrenched views of human behavior, and that these views are too strongly supported by current psychology" (p. 948). I find his comments to be very relevant as well as provocative.

My reading of his article shows that he attributes these conflicts to two general factors: (1) our failure to recognize that machines that teach are teaching machines, and are not computers and (2) a commitment of teachers and of teachers of teachers to humanistic and cognitive psychology.

What Do You Call Machines That Teach?

It is important to select an appropriate label because it

a. helps to construct the conceptual framework within which the computer is considered in teaching and testing,

b. helps to determine the attitudes and dispositions to respond in particular ways of the human teachers, and

c. affects the kinds of research and application questions which are formulated.

The label, "computer," tends to focus the attention on the machine rather than upon the purposes for which the machine is being used. Skinner (1984) has suggested that a more satisfactory and more accurate label, is "teaching machine." Skinner makes the point by proposing,

> Computers are now badly misnamed. They were designed to compute, but they are not computing when they are processing words, or displaying PacMan, or aiding instruction.... Instruction may be 'computer aided,' and all good instruction must be 'interactive,' but machines that teach are teaching machines (p. 948).

The concept that the modern teaching machine simply uses computers for the storage and control of information is shared by most learning psychologists. This may be due to the fact that the idea that machines could be used to teach was introduced in psychology in 1926, more than 50 years ago, by E.L. Pressey of Ohio State University. He developed a machine to automatically administer tests and "...made the perceptive observation that the machine could teach as well as test..." (Adams, 1980, p. 194).

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A colleague (Dubois, 1984) suggested to me that the label, "teaching machine", also should be disqualified. In the 1960s, the unkept promises and failures to live up to the heavily advertised advantages of teaching machines produced a backlash and rejection of them. Thus, the label "teaching machine" may have associated with it some residual feelings of past failure and rejection.

Perhaps this is a good place to define teaching and training as the management of a learning situation aimed at the attainment of particular knowledge, skills, attitudes and performance. "Learning" may be defined here as a relatively permanent change in the behavioral potential of a person which accompanies practice. Sometimes the learning objectives may not be very well specified, but that is another topic. A "systems approach" (or general systems theory) helps to maintain one's focus on the purpose of teaching and education and helps to maintain an appropriate perspective for considering teaching machines and computers--or whatever we decide to label these machines.

A Systems Approach to Teaching

During the 1950s there emerged in many military, industrial and academic settings an increasing recognition of the importance of what may be called a "systems approach." One central idea of the systems approach, which started in engineering many years before, is that two or more components interact and communicate with each other in order to attain a common purpose. This kind of approach was being employed by ergonomics scientists to conceptualize the human as a component which interacts with machines (and other people) to attain a common purpose.

Over the past several decades general systems theory has undergone considerable development. The most elaborate and recent application of systems theory to the human being is probably contained in J. G. Miller's "Living Systems" (1978).

However, the behavioral, educational and social sciences, in contrast to the medical and biological sciences, have been slow in adopting the systems concepts and incorporating them as tools for advancing their scientific and professional condition. For example, only in the last several years has there been any substantive mention of general systems theory in textbooks in introductory psychology or in any development of behavioral theories (McConnell, 1983). A representation of a systems approach for teaching and some of the components involved are shown in Figure 1.

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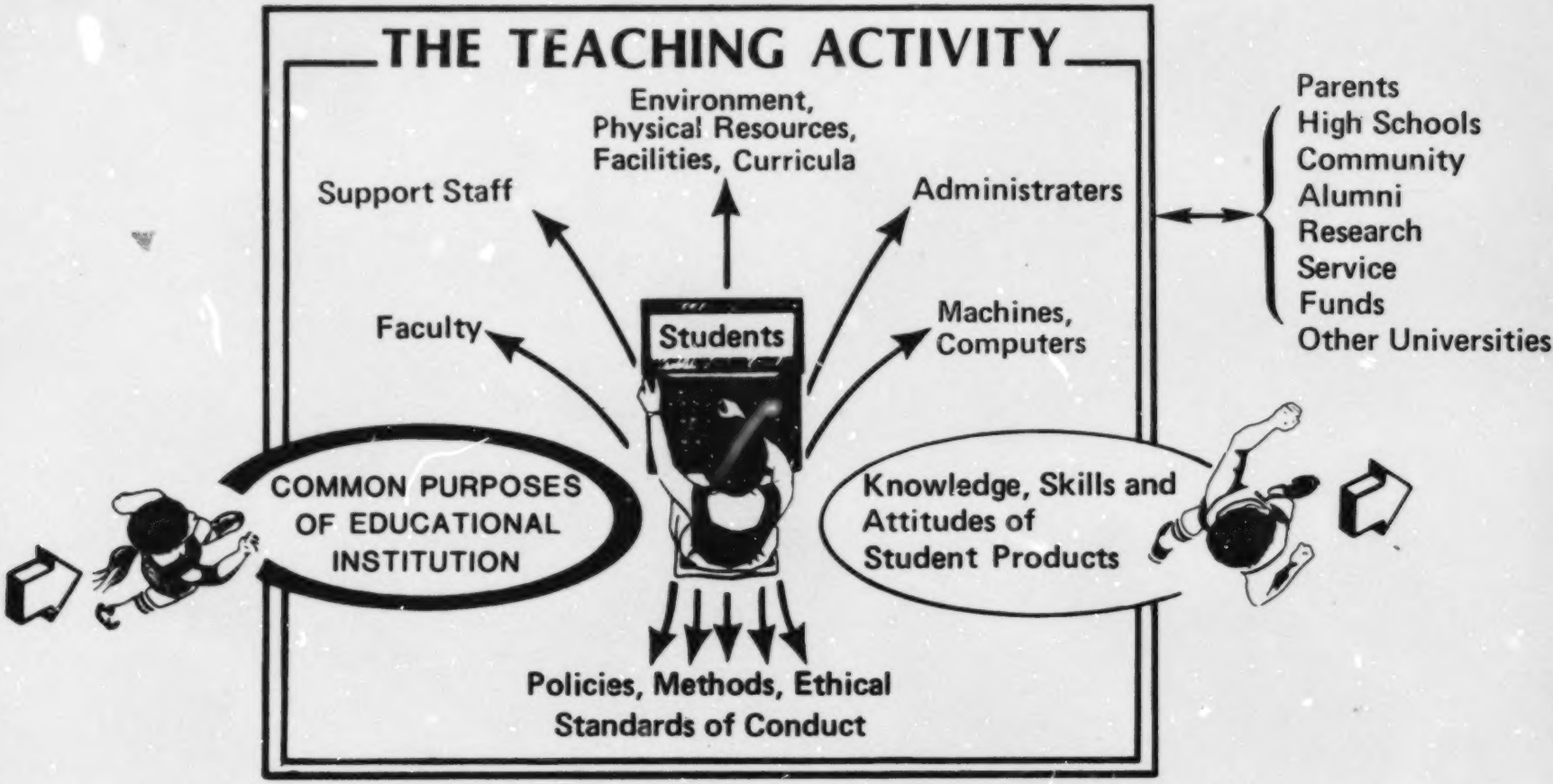

Figure 1. A conceptual framework of the teaching activify in a university as a system of interacting components, all of them having a common purpose.

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I have discussed systems theory in as much detail as I have because it provides a conceptual framework for considering computers in teaching, training and testing. Specifically, computers are considered to be a machine component in a system which consists of other components such as the student/learner, the textbook, the human teacher/trainer, the teaching administrators, the policies, rules and curricula, the ethical standards of behavior which prevail, the environmental factors such as temperature, humidity, noise, and the design of the learning-place equipment such as the desk, seat, informational displays, controller or marking devices and communication modes. For example, there are at least five kinds of devices (light pen, joystick, mouse, trackball and touchpanel) other than the cursor keys on a keyboard which are better for certain purposes (Weissman, 1984) to move a cursor or to mark an area on a monitor screen than are the cursor keys on a computer keyboard (the ones with arrows marked on them).

All of these components combined have a common purpose of the student learning some specified material, e.g., for the student to learn to solve specified problems, to understand some concept or to perform some specified job. In general, the purpose of such a learning and teaching system is to impart some specified knowledge or skills to one or more student learners. Or perhaps, I should say that we should design the teaching system so that it manages the learning circumstances so that the learner's performance potential is altered to be in accordance with the learning objectives.

Consider the first course which I taught in 1962--the statistics course. I delivered well-organized, substantive, interesting lectures for the purpose of the students learning the material from these lectures, the textbook, a workbook, each other, etc. To my great disappointment, the students' performance on the tests were very poor.

An analysis of this teaching problem as a closed loop system led me to the conclusion that one problem was that my interpretation of my observations of the students' behavior, their facial expressions, etc. was inaccurate. Often I believed that they were understanding the lecture material when, in fact, they were not. So an improvement in the accuracy (or validity) of the feedback information to me, the lecturer, should improve the effectiveness of the instruction.

STUDENT SELF-ASSESSMENT: ASSESSING THE CORRECTNESS OF ONE'S OWN RESPONSES

Each classroom student was given a hand-held button, which he/she was told to press when they were not understanding the lecture. These buttons were connected by wires to a meter mounted on my lecture podium which displayed the percentage of students who were pressing their buttons at any moment in time. When the needle on the meter reached too high of a percentage, then I would stop and try to remedy the apparent misunderstanding. It should be noted that the students had to make an assessment of whether they understood or did not understand the lecture in order for them to decide whether to press or not to press the button.

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A consideration of the ability of people to make these kinds of self-assessments led me into a rather extensive program of research and thought concerning the human processes which might underlie this activity and to consider the practical implications of these self-assessment responses. For one thing, my research indicates that simply requiring a learner to indicate "how sure" he/she is of the correctness of each response which is made may speed up learning (Hunt, 1982). More generally and more importantly, the research suggests that the behavior of a person in day-to-day life in homes, work, professions, sciences, sports and leisure, depends on both

a. the knowledge, skills (and attitudes) which a person has acquired from learning and experience, and

b. the ability of a person to assess accurately whether particular knowledge and skills are possessed and whether responses are correct.

Considerable research in the behavioral and educational sciences for a hundred years or so has been directed toward the identification of factors which may help to improve the ability of our educational and training institutions to impart knowledge and skills. However, little systematic or experimental attention has been devoted to what may be called "human self-assessment responding" which is the ability of people to assess the correctness of responses or actions which they are anticipating making--or--which they have already made but not yet received feedback concerning their correctness. Learning might better be thought of as a change in a person's behavior from making Unsure-and-Wrong responses to Sure-and-Correct responses. It is not sufficient, I think, to consider the learning objective simply to make correct responses.

The study of the human self-assessment responding has led me to use machines not only to conduct research, but also to apply some of my research findings. Grants from the U.S. Army Research Institute for the Behavioral and Social Sciences over the past 7-8 years have allowed me to conduct basic research (Hunt, 1984) and to develop many projects, three of which I will discuss today. They are

1. Self-Assessment Multiple Choice Tests

2. Self-Assessment Computer Aided Testing (SACAT)

3. Self-Assessment Computer Aided Review and Instruction (SACAR)

Self-Assessment Multiple Choice Test

This is a pencil-and-paper multiple choice test (see Appendix A) which requires the test taker to mark an answer and also mark "how sure" he is of the correctness of the answer. These answer sheets can be taken to the counter in the NMSU Computer Center where the Answer Sheets are read using the Optic Scanner and scored, by a computer program installed at the Computer Center.

The tests are scored to provide both the conventional percentage correct and a "Self-Assessment Score." The number of points gained or lost

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on an item depends on whether the answer is correct and, logarithmically, on the level of sureness indicated by the students, as shown below.

	Not Sure	x	x	x	Sure
Correct	+1.0	+2.7	+3.7	+4.5	+5.0
Wrong	+0.5	-0.4	-1.6	-3.2	-6.0

Print-outs (which can be used for the purposes shown) are provided to the instructor as follows:

a. Student Listing giving only Social Security Numbers with no names (For posting to provide feedback information to the students)

b. Frequency Distributions for Percentage Correct and for SA Scores (For posting to help students to interpret their scores and letter grades)

c. Instructor Listing giving students' names as well as Social Security Numbers

d. Item-by-Item Information giving the percentage of students who were Sure-and-Correct, the percentage of students who were Sure-but-Wrong, etc. (To help the instructor detect misinformation, evaluate the teaching effectiveness, identify instructional problems, etc. For example, if a particular test item has an unusually high percentage of Sure-but-Wrong answers then the students may be misinformed rather than merely uninformed; and the teaching methods appropriate for remedying misinformed students may be different than the typical methods designed for teaching the uninformed.)

e. Student Answer Listing of all answers given by all students (To help resolve any questions concerning what answers and self-assessments students gave on the test).

I have employed the knowledge in ergonomics/human factors and engineering psychology in designing the print-outs for the students and instructor.

Self-Assessment Computer Aided Testing (SACAT)

We are just beginning to work on two approaches using self-assessment in a testing situation. One approach is simply computerizing the paper-and-pencil multiple choice test so that students can take the test directly on a computer which (a) provides more rapid feedback to the students concerning their test scores, (b) allows a greater flexibility for the students as to the time when they take the test and (c) provides for the possibility of incorporating the self-assessment methods into other kinds of computerized testing, e.g., randomly selecting from populations of questions.

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The second kind of Self-Assessment Computer Aided Testing method is focused on two aims which are (a) using the self-assessments, along with the correctness of the answer, to detect and identify specific test performance deficiencies and (b) taking advantage of the testing session to serve also as a learning session. The general notion is to consider a person as a "system" consisting of a number of components and processes (Miller, 1978) which interact to produce the individual's performance. The testing strategy is to begin questions, within some topic, at a general level and present questions with increasing specificity aimed at identifying the specific component or process which is responsible for the deficiencies relative to the broad topic or job being tested. The approach is to develop an array of different kinds of questions from which one or more would be presented contingent upon both the self-assessment response and the correctness of the answer. The kinds of questions represent different levels or hierarchies of knowledge of skills which, all combined, are required to perform a specified task or job. Simultaneously an attempt is being made to provide a learning situation to remedy the identified deficiency.

A Self-Assessment Computer Aided Review (and instruction) Program (SACAR)

This approach to teaching machines incorporates my belief (based upon my own and others research findings and thought) that the behavior of people in everyday life importantly depends upon their self-assessments. The human self-assessment process has been not only the focus of my research, but also the focus of my attempts to use computers in teaching training. Because the usual computer keyboard is not suitable for use as a teaching machine by most people, I have designed a student response keyboard specifically for SACAR (See Figure 2), incorporating ergonomics principles of design for the human user.

The keyboard provides for the student to enter their identification number, choose from a menu the specific material which they wish to review or learn, select an answer to each item when it is presented and indicate on a 5-point scale "how sure" they are that the selected answer is correct. The leftmost button is labelled "Not Sure" and the rightmost button is labelled "Sure".

Immediately after an answer to a question and an SA response is given, four items of information are presented on the student's visual display:

a. the answer response which the student gave

b. the correct answer

c. the number of points gained or lost on that item

d. the cumulated number of points so far.

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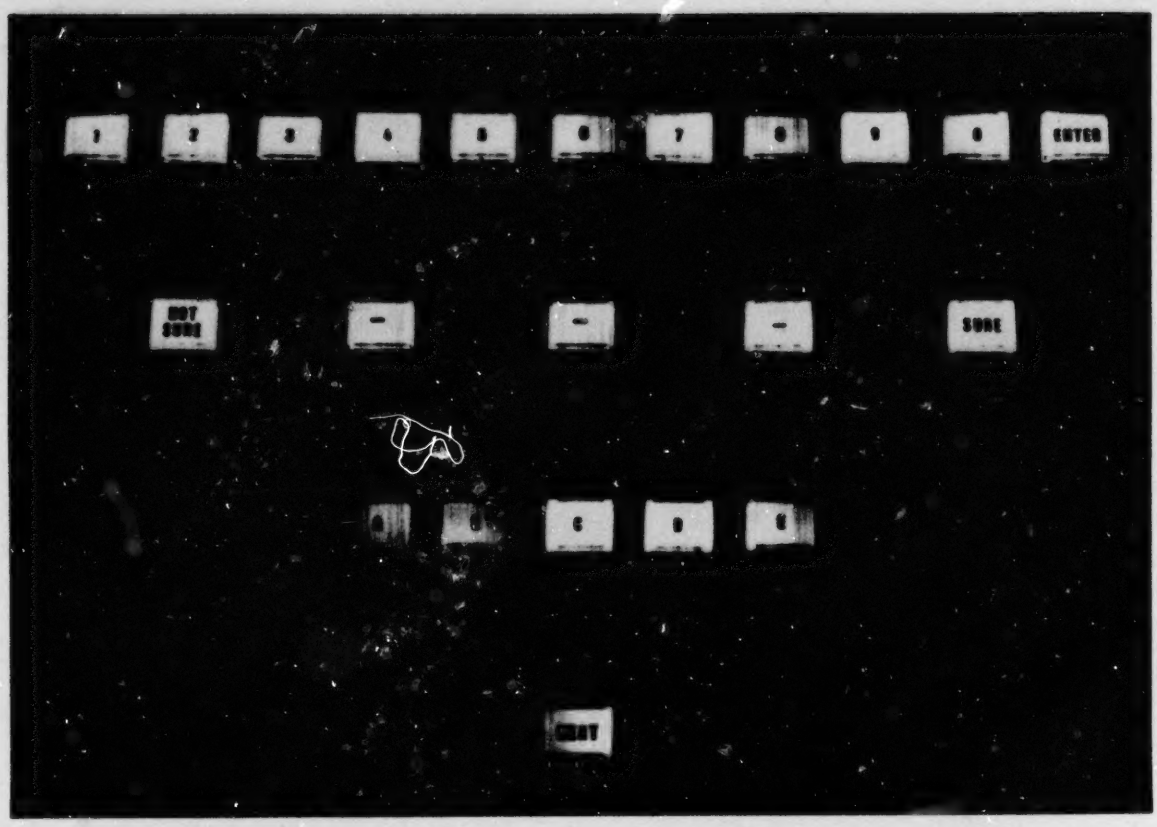

Figure 2. An ergonomically designed keyboard for human learners using the Self-Assessment Computer Aided Review - Instruction (SACAR) machine.

The number of points gained or lost on an item depend on both the correctness of the answer and the accuracy of the self-assessment. The scoring rule for assigning points is the same as is used in the Self-Assessment Multiple Choice Test.

When the student has completed the review of the chosen material, the student is provided information on the visual display concerning (a) the percentage of correct responses to provide feedback to the student concerning the correctness of the answers and (b) an SA score which can range between 0 and 100 to provide feedback to the student concerning the accuracy of their self-assessment responses. This "self-assessment" method could be adopted to almost any computer aided instructional program.

Computer Simulation of Human Self-Assessment Responding

We are also using the computer to construct a simulation of a theoretical model of the human self-assessment process which we have developed. The simulation is called SAM HUMPAT which stands for "self-assessment model of human performance and training." We are committed to what I call a Keplerian approach which emphasizes the incorporation of all that we know about the human perceptual, learning, psychomotor and other

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psychological processes into the simulation. We are not interested in simply constructing a mimic of human self-assessment responding. I call it the Keplerian approach in honor of the inspirational work of Johannes Kepler (e.g., Dreyer, 1953) concerning his laws of planetary motion and it is in contrast to the earlier epicycle models which provide good predictions, but which are based on erroneous concepts of how planets move.

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NCS Trans Optic MB01-17409-321

MULTIPLE CHOICE SELF-ASSESSMENT ANSWER SHEET

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DIRECTIONS:

1. FOR EACH QUESTION, PLEASE SELECT THE BEST ANSWER AMONG THE GIVEN ALTERNATIVES. USING BLACK LEAD PENCIL ONLY, #2½ OR SOFTER, COMPLETELY BLACKEN IN THE CIRCLE CORRESPONDING TO YOUR SELECTED ANSWER. ONLY ONE ANSWER PER QUESTION ALLOWED.
2. IMMEDIATELY AFTER YOU HAVE MARKED YOUR ANSWER, PLEASE INDICATE HOW SURE YOU ARE THAT YOUR ANSWER IS CORRECT BY BLACKENING IN ONE OF THE FIVE LEVELS WHICH IS MOST REPRESENTATIVE OF YOUR CONFIDENCE IN THE CORRECTNESS OF YOUR ANSWER. ONLY ONE CONFIDENCE RESPONSE IS ALLOWED.
3. THE POINTS YOU RECEIVE ON EACH ITEM ARE BASED ON BOTH THE CORRECTNESS OF THE ANSWER AND THE ACCURACY OF YOUR SELF-ASSESSMENT. INDICATING HOW SURE YOU ARE AS ACCURATELY AS YOU CAN WILL PRODUCE THE HIGHEST SCORE.
4. DO NOT FOLD OR STAPLE THIS SHEET. MAKE NO STRAY MARKS AND ERASE CLEAN ANY MARK YOU WISH TO CHANGE.

WRITE IN SOCIAL SECURITY NUMBER IN SPACE PROVIDED. BLACKEN IN CIRCLE BELOW CORRESPONDING TO NUMBER ENTERED.

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

EXAMPLE: ANSWER: T, F, A, B, C, ●, E, F, G, H, I, J — HOW SURE ARE YOU? 0, 1, 2, ●, 4

YOUR ANSWER IS (D) AND YOU ARE FAIRLY CERTAIN (3) THAT YOUR ANSWER IS CORRECT

DO NOT MARK IN THIS SPACE – FOR COMPUTER CENTER USE ONLY ● ●

NAME _____ DATE _____

COURSE TITLE _____ INSTRUCTOR _____

	ANSWER	HOW SURE ARE YOU? ALMOST GUESS	PROBABLE GUESS	NEUTRAL	FAIRLY CERTAIN	ALMOST CERTAIN
1	T F A B C D E F G H I J	0	1	2	3	4
2	T F A B C D E F G H I J	0	1	2	3	4
3	T F A B C D E F G H I J	0	1	2	3	4
4	T F A B C D E F G H I J	0	1	2	3	4
5	T F A B C D E F G H I J	0	1	2	3	4
6	T F A B C D E F G H I J	0	1	2	3	4
7	T F A B C D E F G H I J	0	1	2	3	4
8	T F A B C D E F G H I J	0	1	2	3	4
9	T F A B C D E F G H I J	0	1	2	3	4
10	T F A B C D E F G H I J	0	1	2	3	4
11	T F A B C D E F G H I J	0	1	2	3	4
12	T F A B C D E F G H I J	0	1	2	3	4
13	T F A B C D E F G H I J	0	1	2	3	4
14	T F A B C D E F G H I J	0	1	2	3	4
15	T F A B C D E F G H I J	0	1	2	3	4
16	T F A B C D E F G H I J	0	1	2	3	4
17	T F A B C D E F G H I J	0	1	2	3	4
18	T F A B C D E F G H I J	0	1	2	3	4
19	T F A B C D E F G H I J	0	1	2	3	4
20	T F A B C D E F G H I J	0	1	2	3	4
21	T F A B C D E F G H I J	0	1	2	3	4
22	T F A B C D E F G H I J	0	1	2	3	4
23	T F A B C D E F G H I J	0	1	2	3	4
24	T F A B C D E F G H I J	0	1	2	3	4
25	T F A B C D E F G H I J	0	1	2	3	4
26	T F A B C D E F G H I J	0	1	2	3	4
27	T F A B C D E F G H I J	0	1	2	3	4
28	T F A B C D E F G H I J	0	1	2	3	4
29	T F A B C D E F G H I J	0	1	2	3	4
30	T F A B C D E F G H I J	0	1	2	3	4